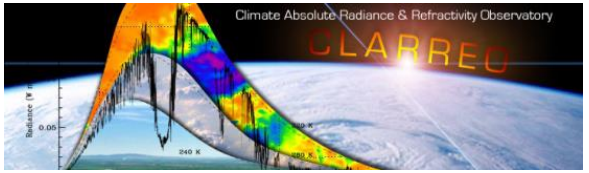

Status of S-NPP VIIRS Solar and Lunar Calibration

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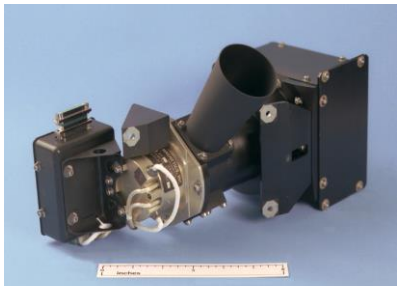
Outline

- **Solar and Lunar Calibration**
  - Strategies and Activities
  - Methodologies
- **Performance Updates**
  - On-orbit Changes and Performance Updates (Improvements)
  - Comparison of Solar and Lunar Calibration
- **Future Efforts**
- **Summary**

Solar and Lunar Calibration Strategies and Activities

15 RSB: M1-M11, I1-I3, DNB
H/L gains: M1-5 and M7
λ: 0.4-2.3 μm

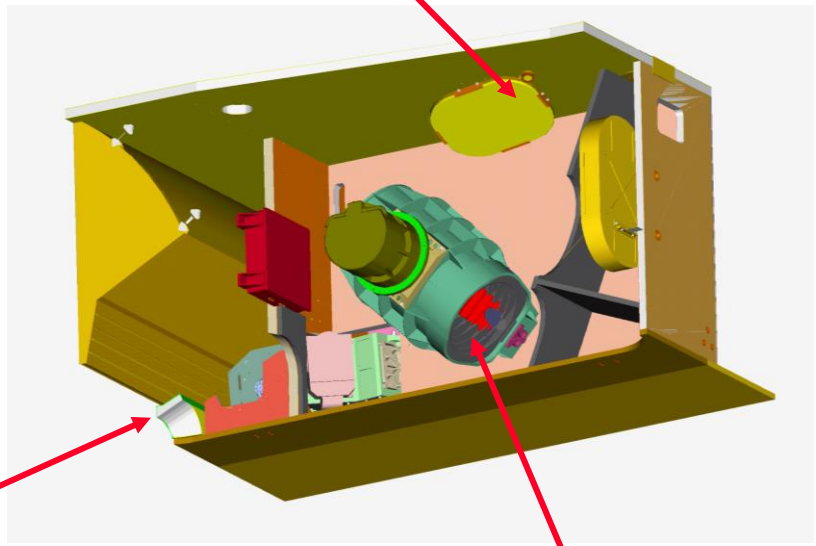
Solar Diffuser
Stability Monitor



SD with a fixed screen

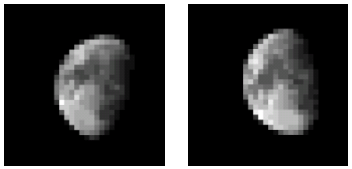
SD calibration each orbit

Daily operation => 3 per week
(8 min => 5 min)
Future reduction of frequency
and operation time



8-9 / year

SC roll maneuver
Same phase angle



Extended SV Port

Rotating Telescope Assembly (RTA)

Solar Calibration Methodologies

Quadratic Approach

VIIRS Radiance (L) Retrieval: $L = F \cdot L_{PL} = F \cdot \left(c_0 + c_1 \cdot dn + c_2 \cdot dn^2\right) / RVS$

F: Calibration scaling factor derived from on-orbit calibration

c_i: Pre-launch calibration coefficients (quadratic algorithm)

RVS: Sensor response versus scan-angle

Reflectance Based

VIIRS Solar Calibration: $F_{SD} = \dfrac{L_{SUN}}{L_{SD,PL}}$ $L_{SUN} \propto \cdot E_{SUN} \cdot BRDF(t) \cdot \tau_{SDS} \cdot \cos(\theta_{inc})$

L_{SUN}: Expected solar radiance reflected from SD panel

$L_{SD,PL}$: Retrieved solar radiance using pre-launch calibration coefficients

SD Degradation (H): $BRDF(t) = H_{Norm}(t) \cdot BRDF(t_0)$

Lunar Calibration Methodologies

VIIRS Lunar Calibration: $$F_{MOON} = \frac{I_{ROLO}}{I_{MOON,PL}} = \frac{I_{ROLO}}{\sum_{\det,sam,scan} L_{MOON,PL} \cdot \Omega_B \cdot g / N_{SCAN}}$$

I_{ROLO}: Lunar irradiance (integrated) provided by ROLO model
$I_{MOON,PL}$: Lunar irradiance retrieved using pre-launch calibration coefficients
N_{SCAN}, Ω_B, g: number of scans, pixel solid angle, aggregation factor

Ongoing and Future Activities for Lunar Model Improvements:

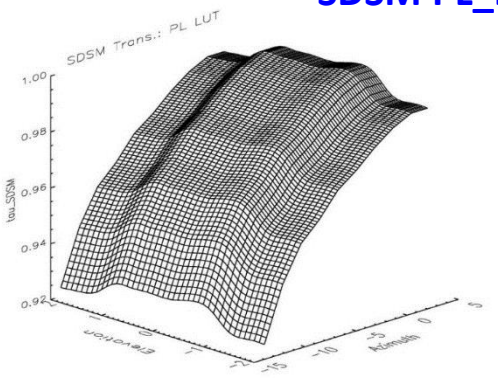
- USGS ROLO (Stone/Kieffer)
- NIST high accuracy measurements (Brown et al)
- CNES POLO data

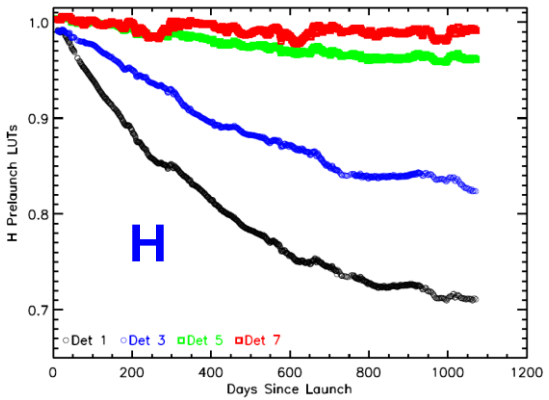
On-orbit Changes and Updates (Improvements)

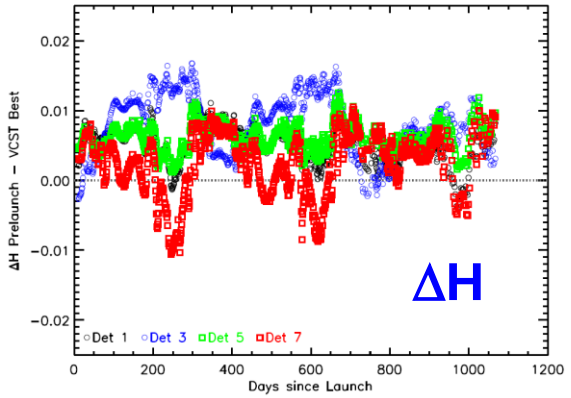
- **SD and SDSM Screen Transmission**
  - Pre-launch characterization
  - On-orbit yaw maneuvers
  - Yaw + regular on-orbit data
- **Correction for Solar Vector Error**
  - Consistently reprocessed SDR for NASA science research community
  - Different impact for VIS/NIR and SWIR
- **Modulated RSR (relative spectral response)**
  - Due to strong wavelength-dependent optics degradation
  - Different impact for solar and lunar calibration, and EV data
  - Large effect for DNB (broad bandwidth: 500-900 nm) calibration

SD and SDSM Screen Transmission (LUTs)

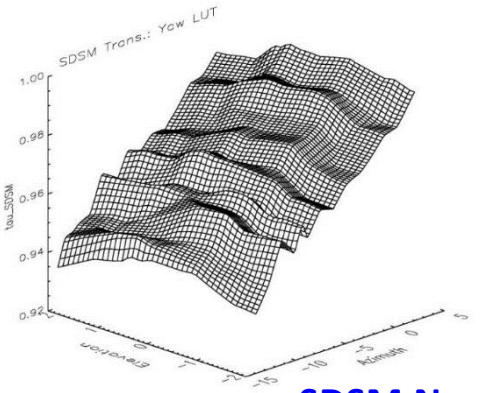
SDSM PL_LUT

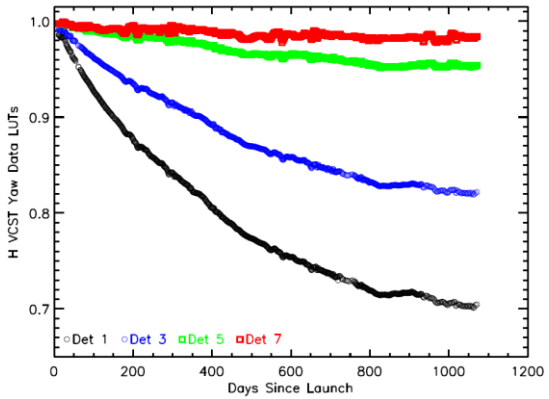


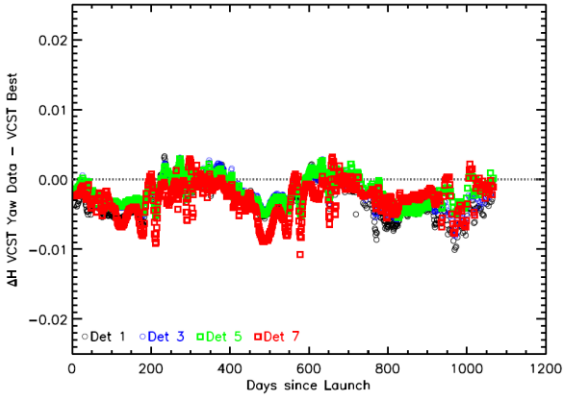




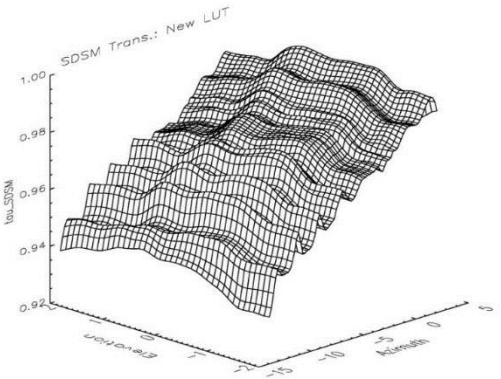
SDSM Yaw_LUT

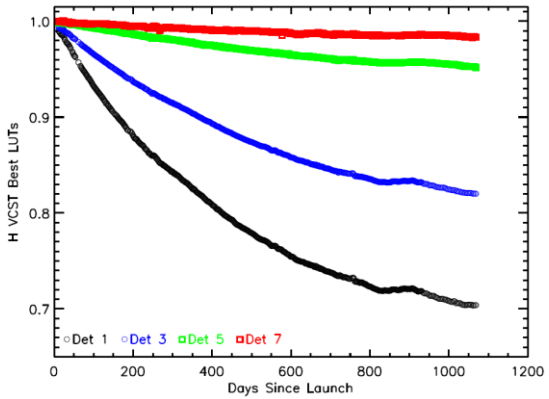






SDSM New_LUT





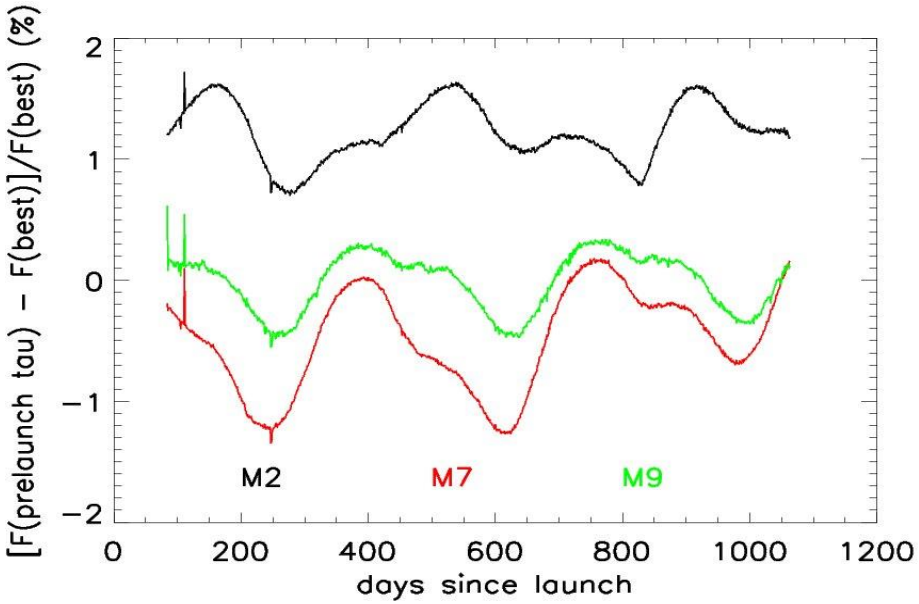
Improved H => better quality of F

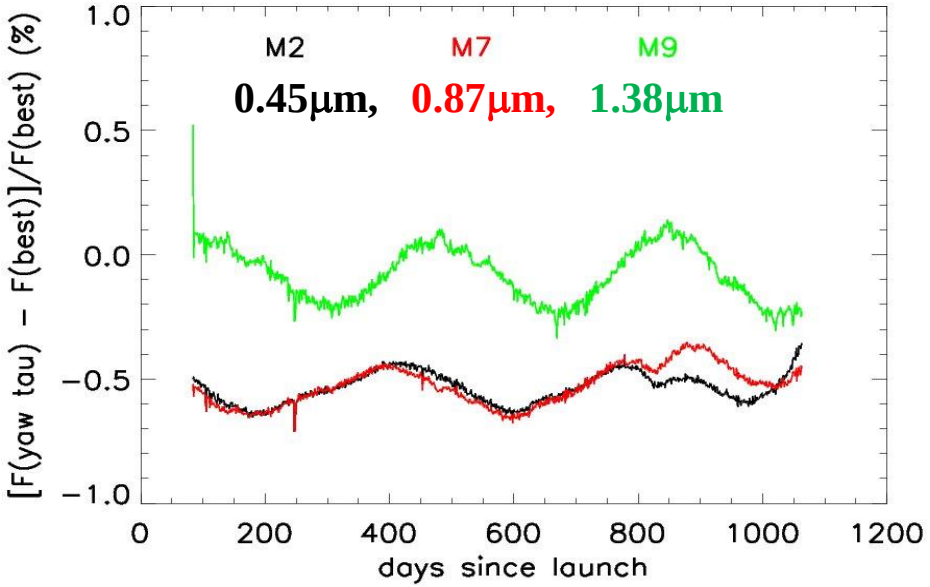
Similar improvements to SD screen transmission

0.41, 0.48, 0.67, 0.86 μm

SD and SDSM Screen Transmission (LUTs)

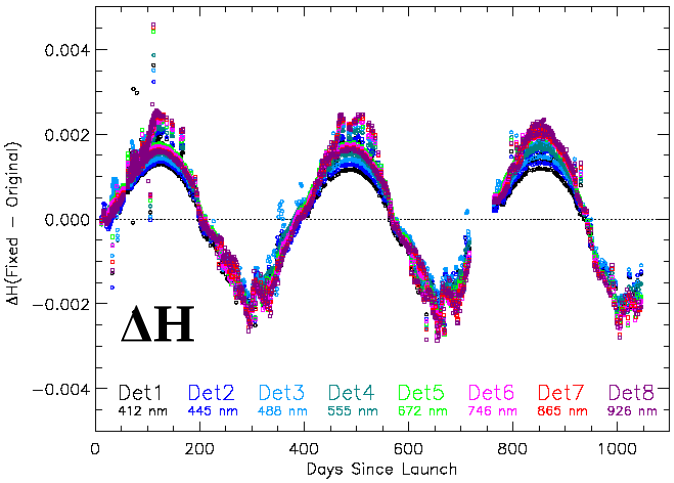
Impact on F-factor (1/Gain)

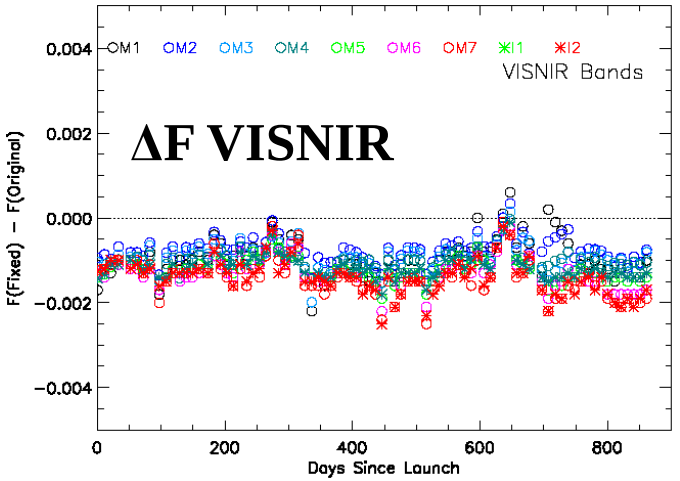


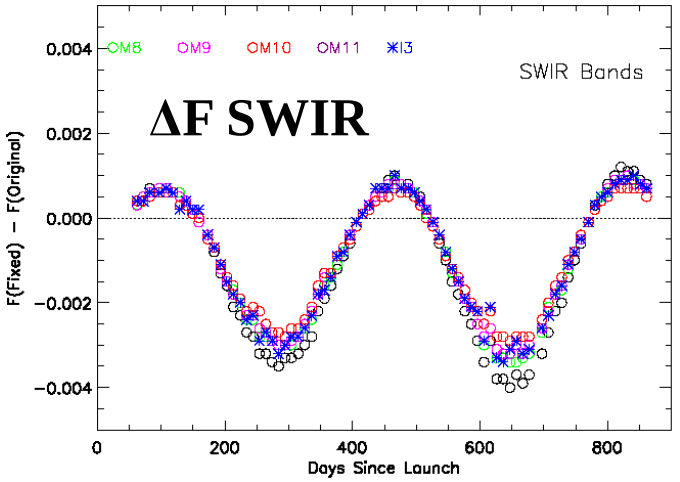


Correction for Solar Vector Error in SDR Geo Library

- **A mismatch of ECI (Earth-Centered Inertial) frames when computing the transformation to spacecraft frame library leads to ~0.2º error in the solar angles used in the RSB radiometric calibration.**
- **Different impact for VIS/NIR and SWIR bands**

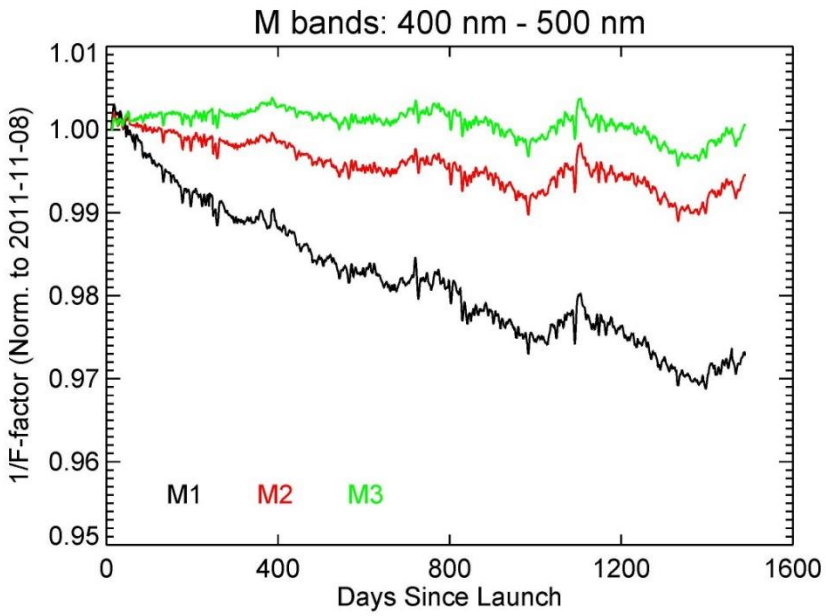


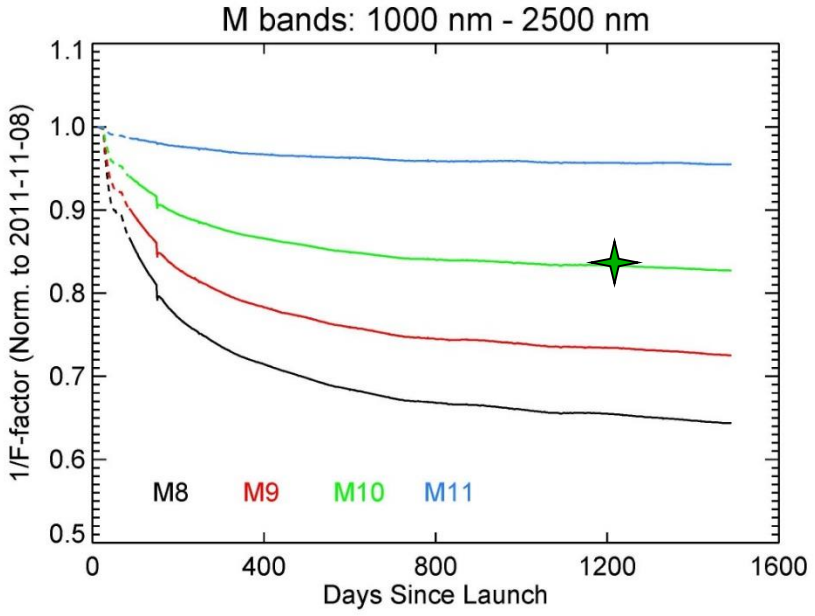


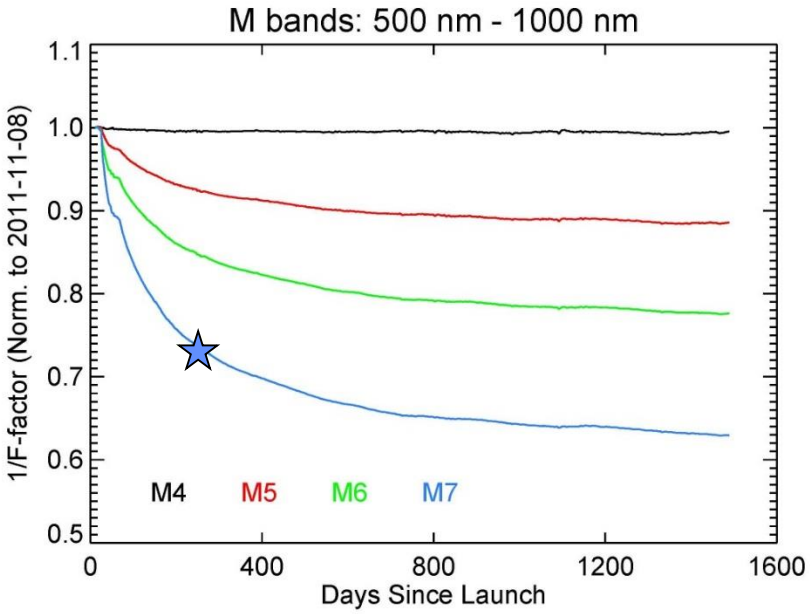


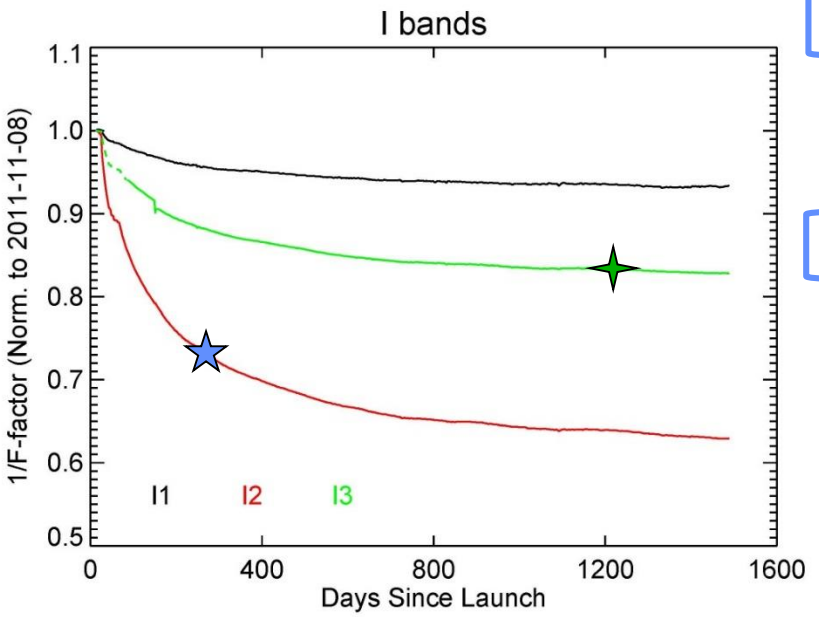
- **The cos θ_{SD} factor is used in both H- and F-factor calculations.**

SD F-factors for VIIRS Reflective Solar Bands







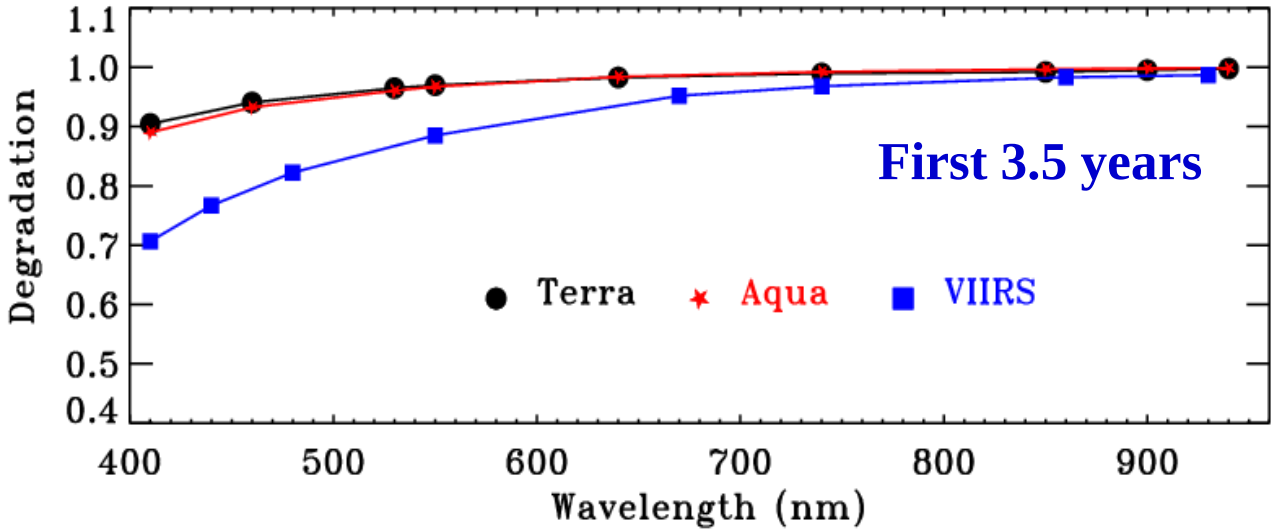


M1	0.41
M2	0.45
M3	0.49
M4	0.56
I1	0.64
M5	0.67
M6	0.75
I2	0.87
M7	0.87
M8	1.24
M9	1.38
I3	1.61
M10	1.61
M11	2.25

Solar Diffuser and Optics Degradation

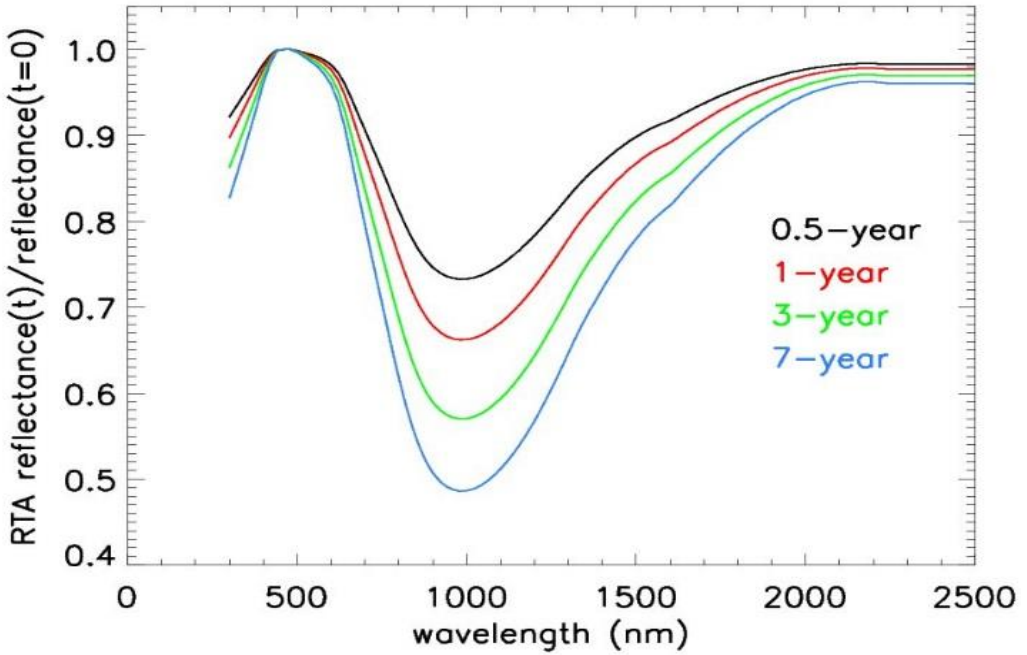
SD degradation:

Large at short wavelength



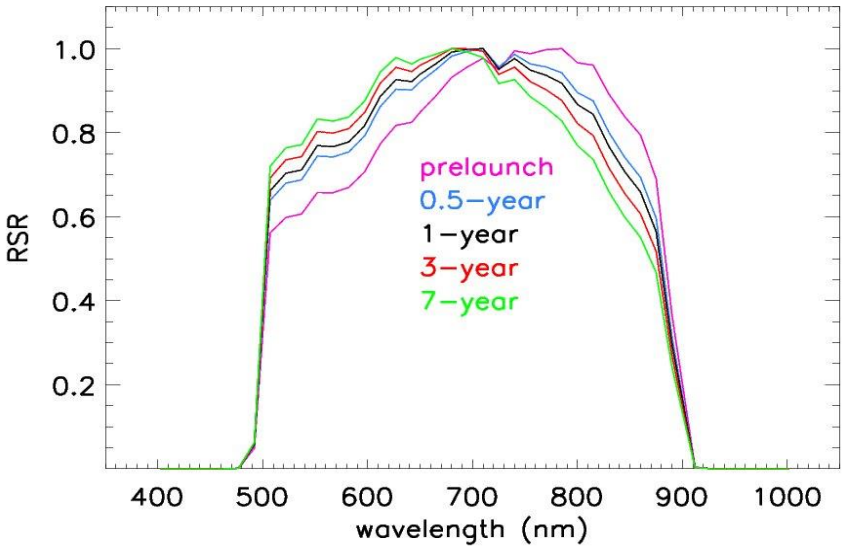
Optics degradation:

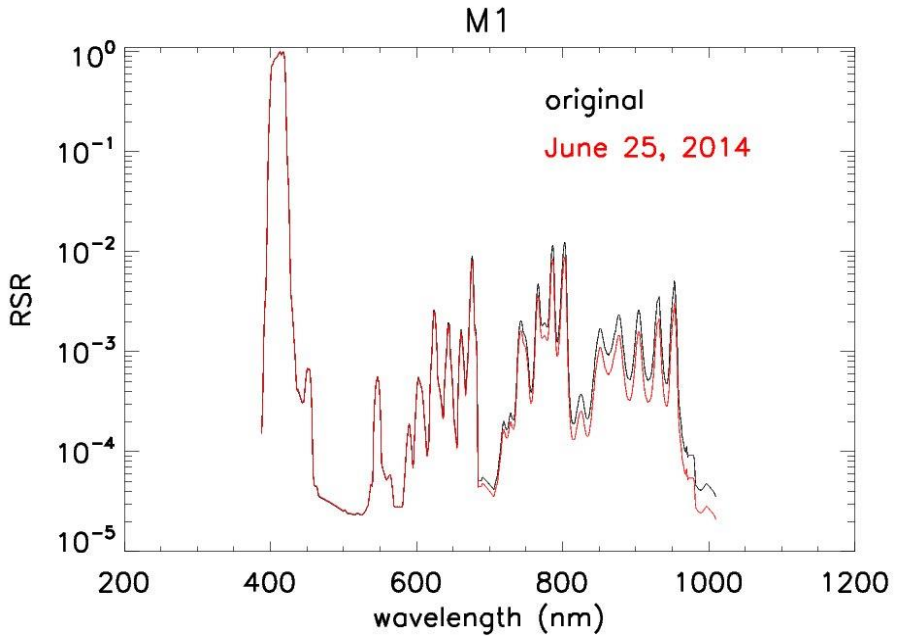
Large at NIR/SWIR

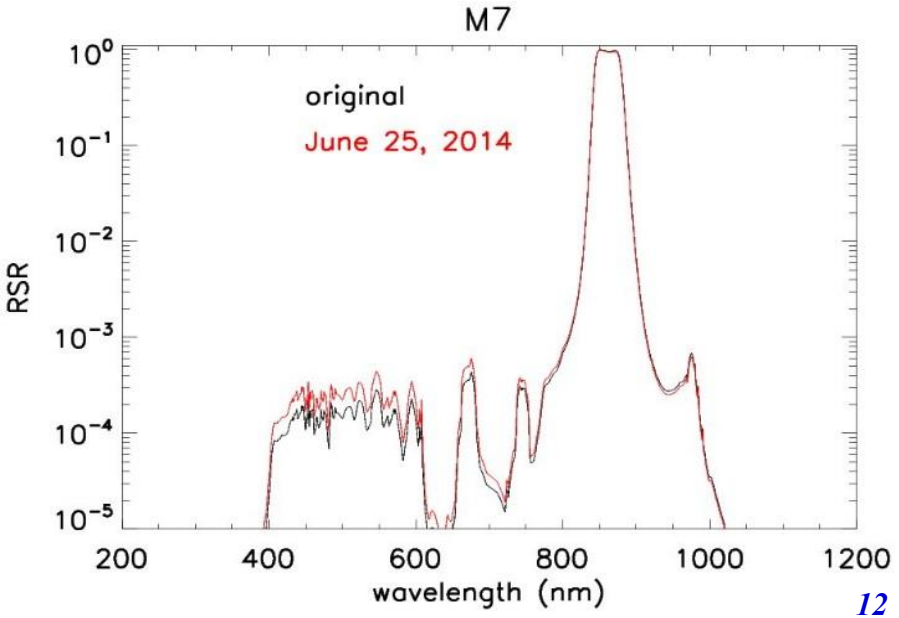


Development and Update of On-orbit Modulated RSR

Time-dependent RSR



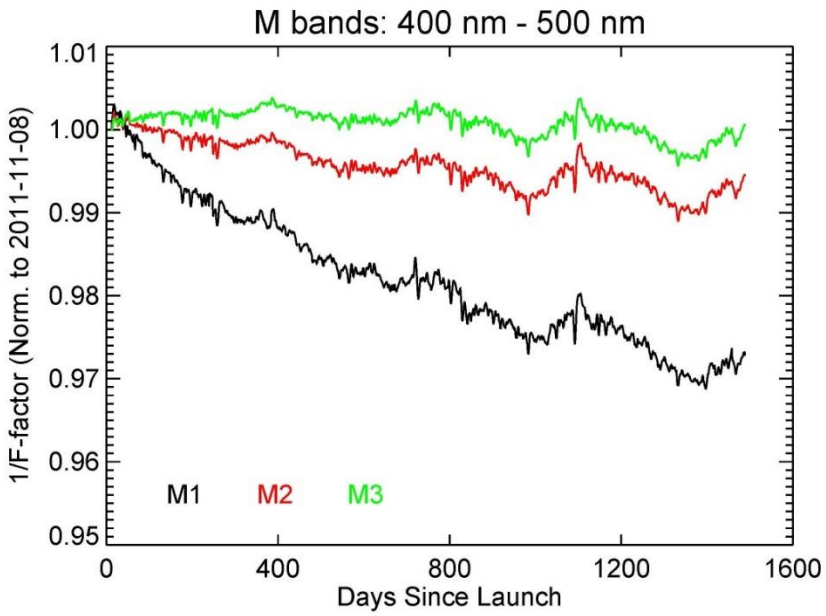


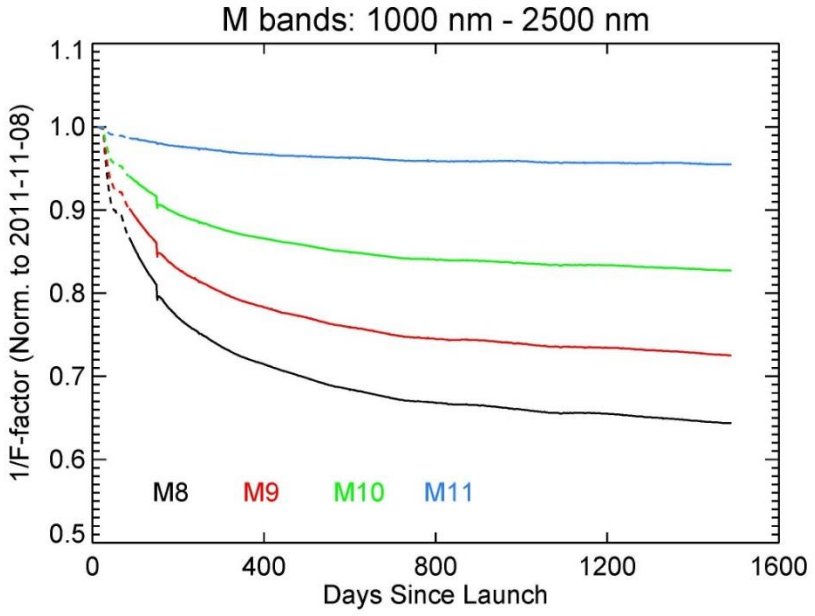


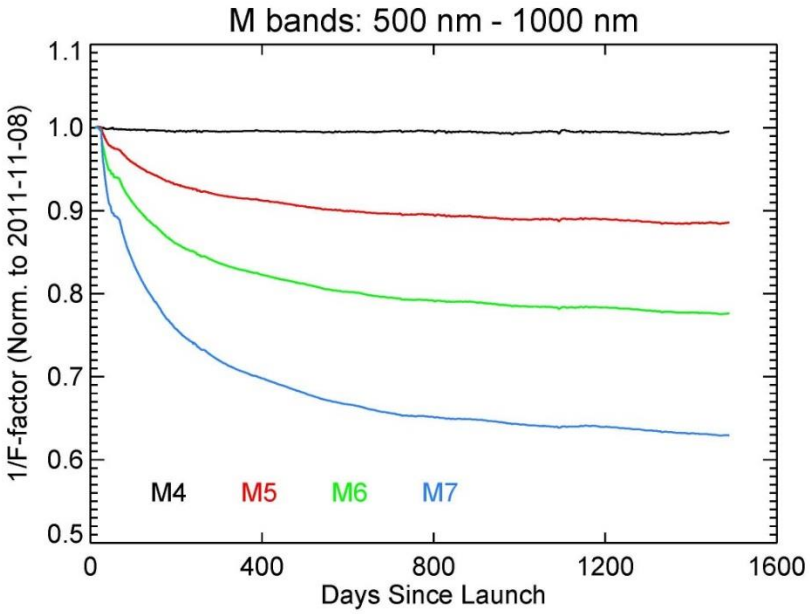
Large impact on DNB with a broad bandwidth

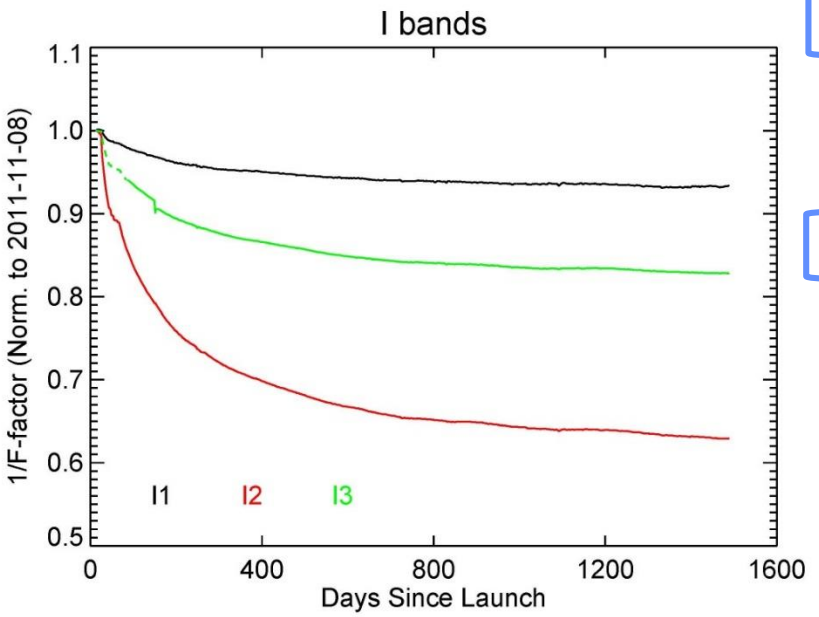
Small impact on bands with narrow bandwidths and non-negligible OOB responses

SD F-factors for VIIRS Reflective Solar Bands









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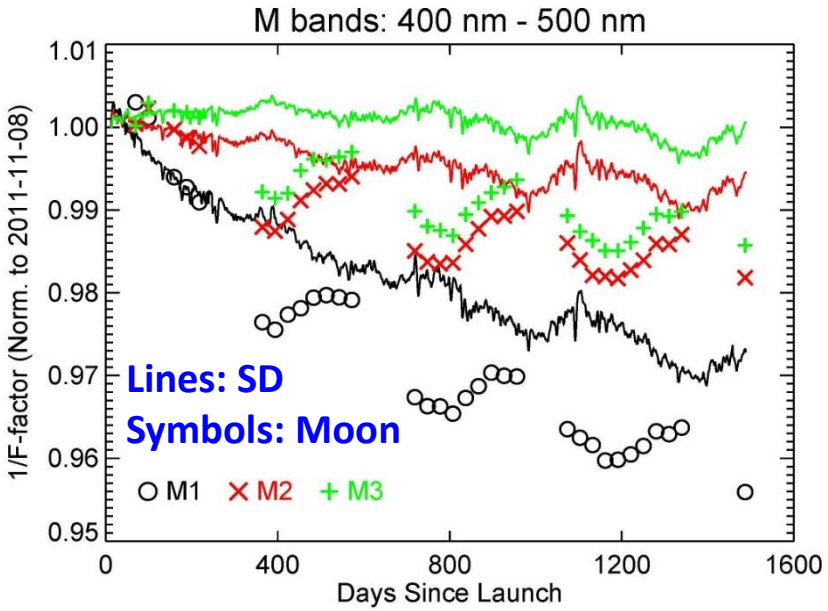
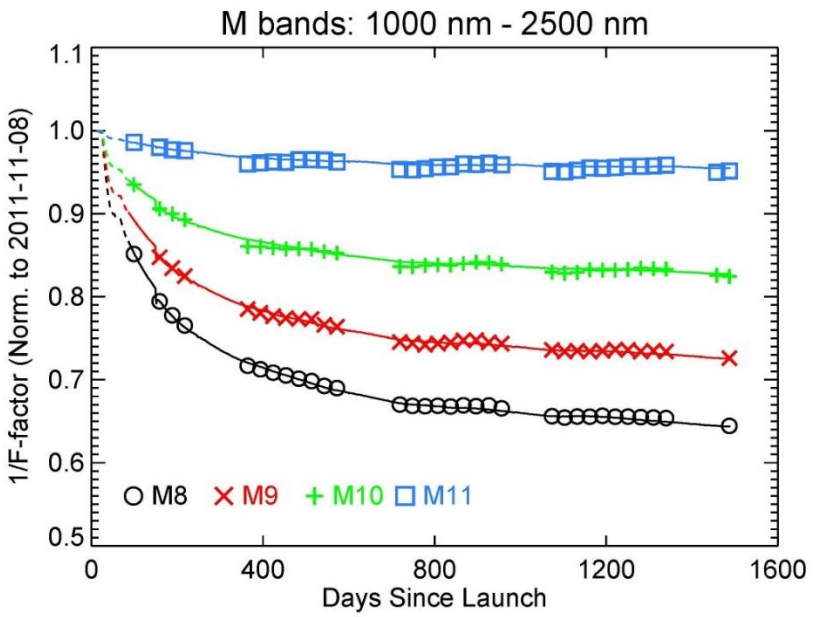
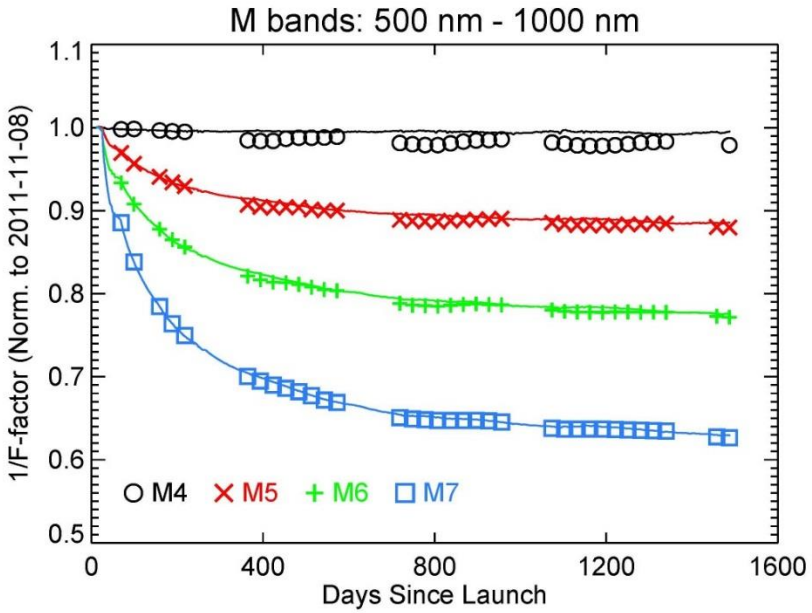
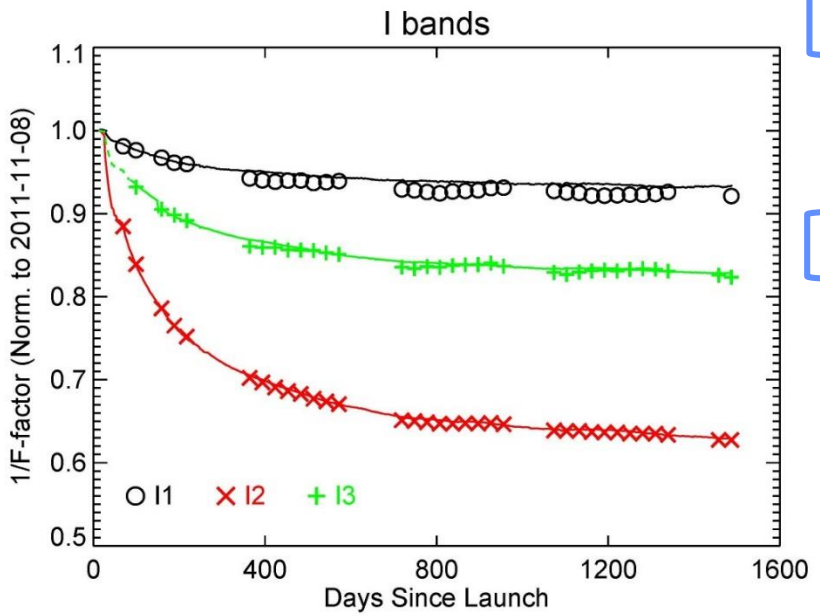
SD and Lunar F-factors for VIIRS Reflective Solar Bands









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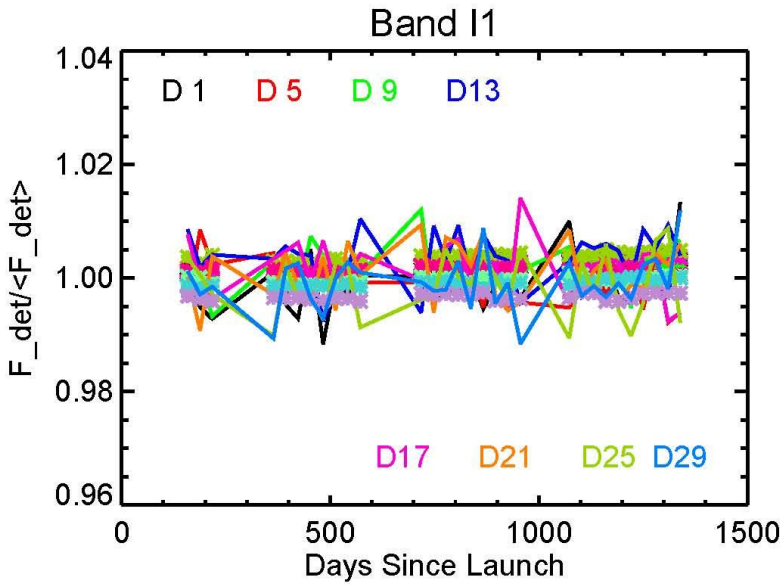
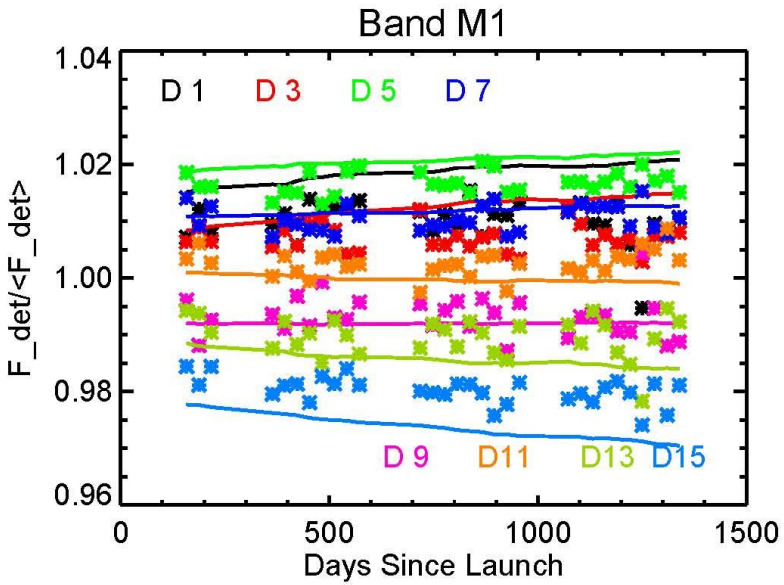
M11	2.25

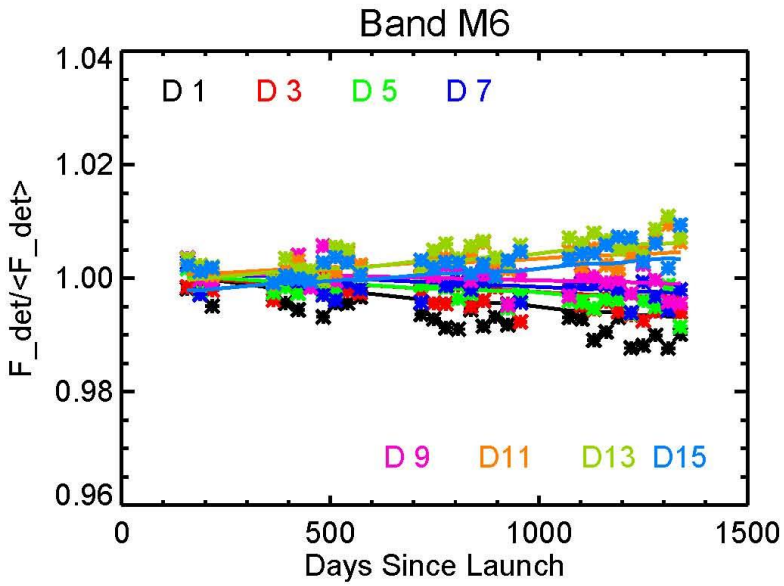
Future Efforts

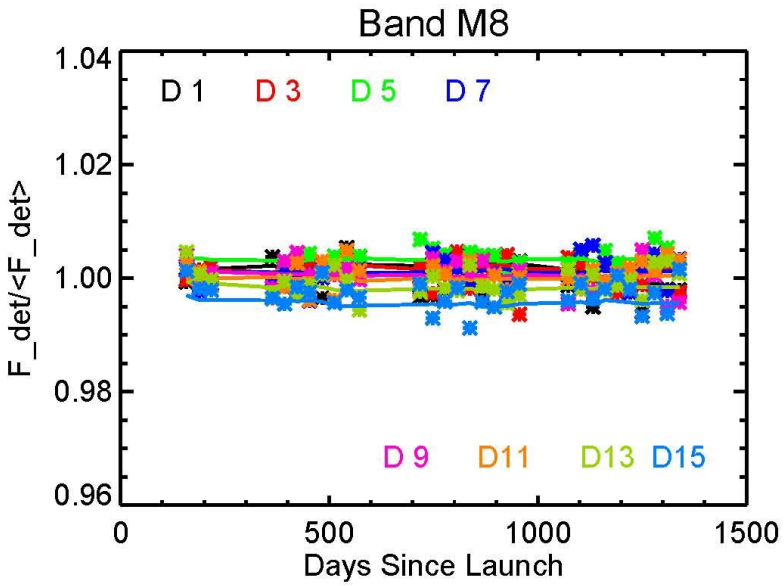
- **Combine SD and Lunar Calibration for Improved SDR LUTs**
  - SD and lunar observations are made at the same AOI
  - Remove potential impact due to SD degradation (SDSM and SD degradation uniformity)
- **Use Lunar Observations to and Characterize and Reduce Detector to Detector Calibration Differences**
  - Similar strategy developed and applied for MODIS calibration
  - Small differences in a few VIIRS spectral bands
- **Improve Lunar Calibration**
  - Absolute - effort by NIST/USGS (goal: 0.5%) and by GSICS/USGS (goal: 2%)
  - Relative - response trending and calibration inter-comparison

Detector to Detector Calibration Differences



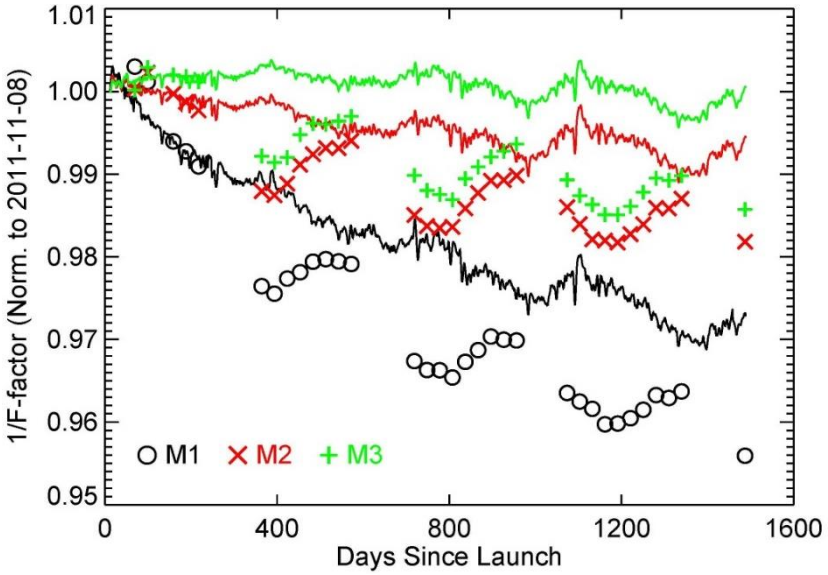


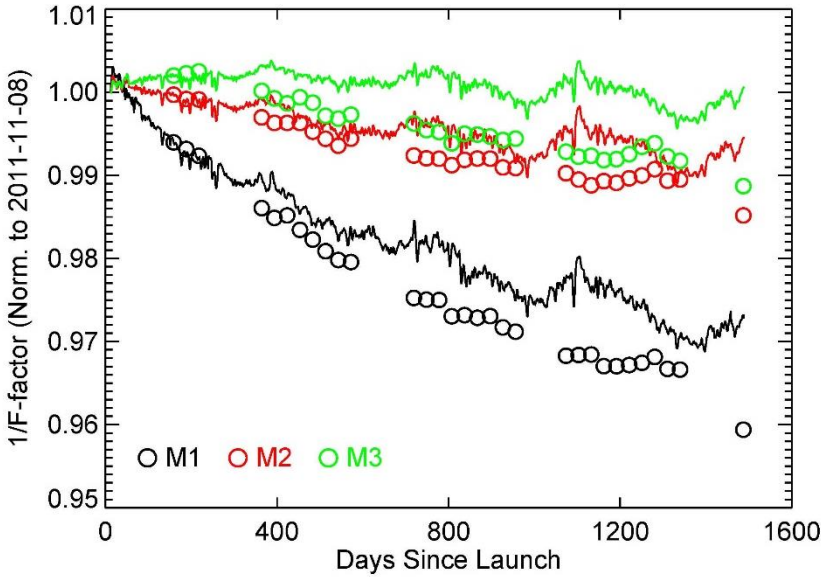




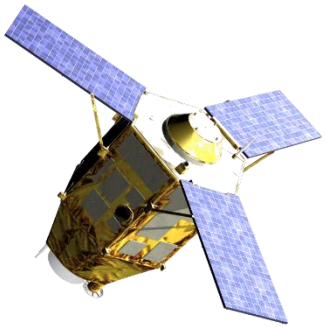
Approaches for Lunar Calibration Improvements

With an empirical libration correction

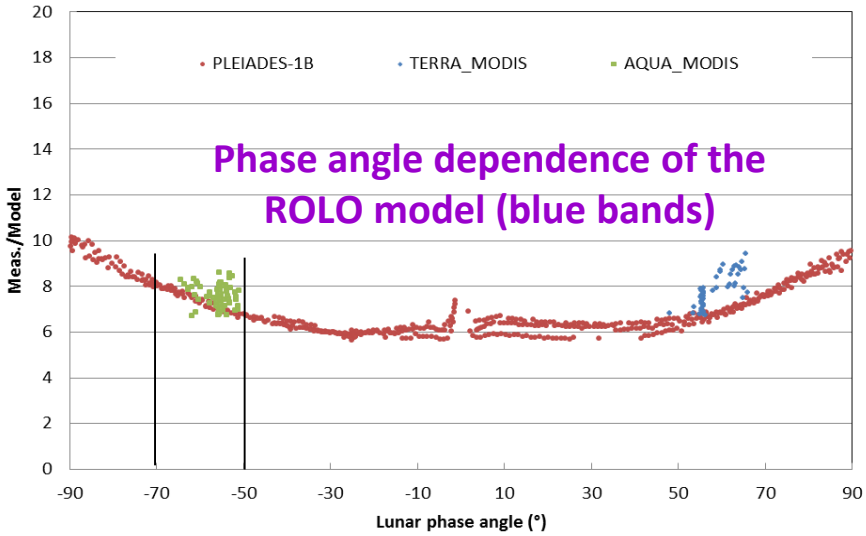




Impact due to lunar phase angles



Pleiades: POLO



Summary

- **S-NPP VIIRS continues to perform well, meeting the need for operational users (SDRs/EDRs from IDPS) and science community (reprocessed SDRs/EDRs)**
  - NASA VCST and SIPS effort
  - NOAA reprocessing plan
- **Improved understanding of both solar and lunar calibration led to generation of consistent LUTs and high-quality data products**
- **Future efforts planned to address various challenging issues**
  - Near-term
  - Long-term